CLAIMS

What is claimed is:

1. A brushless dc (BLDC) motor speed control apparatus, comprising:

a speed determination unit to determine fluxes of respective phases of currents driving a three phase BLDC motor, measure a period of the determined flux changes, and determine a speed of the BLDC motor;

a subtractor to subtract an inputted reference speed and the determined speed outputted from the speed determination unit, and output an error speed;

a speed controller to output a reference current corresponding to the error speed outputted from the subtractor;

a current controller to output a switching control signal based on the reference current outputted from the speed controller; and

an inverter to drive the BLDC motor with a current of variable frequency based on the switching control signal outputted from the current controller.

2. The apparatus as claimed in claim 1, wherein the speed determination unit comprises:

a flux determination unit to determine fluxes based on induced voltages and currents of windings corresponding to the respective phases of the BLDC motor; and

a speed calculation unit to measure specific periods of the fluxes of the respective phases outputted from the flux determination unit, and determine a speed of the BLDC motor.

3. The apparatus as claimed in claim 2, wherein the flux determination unit comprises:

a current detector to detect the induced voltages and currents corresponding to the respective phases of the current driving the BLDC motor;

a phase transformer to transform the induced voltages and currents of the respective phases into induced voltages and currents of first and second transformed phases; and

a flux determiner to determine the flux based on the induced voltages and currents of the first and second transformed phases outputted from the phase transformer.

4. The apparatus as claimed in claim 3, wherein:

the phase transformer transforms the three phases of the BLDC motor into two phases employing the formulas:

$$V_\alpha = V_a$$
$$V_\beta = \frac{2V_b + V_a}{\sqrt{3}}$$
$$I_\alpha = I_a$$
$$I_\beta = \frac{2I_b + I_a}{\sqrt{3}}$$

where, V_α and V_β respectively indicate induced voltages corresponding to the first and second transformed phases, I_α and I_β respectively indicate induced currents corresponding to the first and second transformed phases, V_a and V_b respectively indicate voltages induced in two phases of the three phases of the BLDC motor, and I_a and I_b respectively indicate currents induced in the two phases of the three phases of the motor.

5. The apparatus as claimed in claim 3, wherein:

the flux determiner determines fluxes with respect to the first and second transformed phases employing the formulas:

$$\Psi_\alpha = \int (V_\alpha - R_s I_\alpha) dt$$
$$\Psi_\beta = \int (V_\beta - R_s I_\beta) dt$$

where, Ψ_α indicates the flux of the first transformed phase, Ψ_β indicates the flux of the second transformed phase, V_α indicates an induced voltage of the first transformed phase, V_β indicates an induced voltage of the second transformed phase, R_s indicates the winding resistance of the motor, I_α indicates an induced current of the first transformed phase, and I_β indicates an induced current of the second transformed phase.

6. The apparatus as claimed in claim 5, wherein the speed calculation unit comprises:

a timer to measure a period during which the fluxes of the first and second transformed phases outputted from the flux determiner become a predetermined value; and

a speed determiner to determine a rotation speed of the BLDC motor based on the period outputted from the timer.

7. The apparatus as claimed in claim 6, wherein:

the speed determiner measures a time interval during which both of the fluxes of the first and second transformed phases become '0'.

8. The apparatus as claimed in claim 7, wherein the speed determiner determines the speed employing the formula:

$$\omega = \frac{\pi}{2T_0}[radian/\sec]$$

where T_0 denotes the time interval during which both of the fluxes of the first and second transformed phases become '0', and ω denotes an angular velocity of the BLDC motor.

9. A brushless DC (BLDC) motor speed control method, comprising:

determining a speed of a BLDC motor based on a period in which flux values of respective phases of a current driving the BLDC motor become a specific value;

determining an error speed based on an inputted reference speed and the determined speed;

outputting a reference current corresponding to the determined error speed;

outputting a switching control signal to drive the motor based on the outputted reference current; and

driving the motor with a current of variable frequency based on the switching control signal.

10. The method as claimed in claim 9, wherein the determining the speed of the BLDC motor based on the period in which flux values of the respective phases of the current driving the BLDC motor become the specific value comprises:

determining fluxes corresponding to the respective phases of the current driving the BLDC motor; and

determining a speed of the BLDC motor based on a time interval during which both of the respective determined fluxes becomes '0'.

11. The method as claimed in claim 10, wherein the determining fluxes corresponding to the respective phases of the current driving the BLDC motor comprises:

determining voltages and currents induced in two phases of three phases of the BLDC motor;

transforming the determined voltages and currents induced in the two phases into voltages and currents of first and second transformed phases; and

determining fluxes of the first and second transformed phases.

12. The method as claimed in claim 11, wherein:

the transforming the determined voltages and currents induced in the two phases into the voltages and currents of the first and second transformed phases employs the formulas:

$$V_\alpha = V_a$$

$$V_\beta = \frac{2V_b + V_a}{\sqrt{3}}$$

$$I_\alpha = I_a$$

$$I_\beta = \frac{2I_b + I_a}{\sqrt{3}}$$

where, V_α and V_β respectively indicate induced voltages corresponding to the two transformed phases, I_α and I_β respectively indicate induced currents corresponding to the two transformed phases, V_a and V_b respectively indicate voltages induced in two phases of the three phases of the BLDC motor, and I_a and I_b respectively indicate currents induced in the two phases of the three phases of the motor.

13. The method as claimed in claim 12, wherein:

the determining the fluxes of the first and second transformed phases employs the employs the formulas:

$$\Psi_\alpha = \int (V_\alpha - R_s I_\alpha) dt$$

$$\Psi_\beta = \int (V_\beta - R_s I_\beta) dt$$

where, Ψ_α indicates the flux of the first transformed phase, Ψ_β indicates the flux of the second transformed phase, V_α indicates an induced voltage of the first transformed phase, V_β indicates an induced voltage of the second transformed phase, R_s indicates the winding resistance of the motor, I_α indicates an induced current of the first transformed phase, and I_β indicates an induced current of the second transformed phase.

14. The method as claimed in claim 13, wherein:

the determining the speed of the BLDC motor employs the formula:

$$\omega = \frac{\pi}{2T_0}[radian/\sec]$$

where, T_0 denotes a time interval during which both of the fluxes of the two transformed phases becomes '0', and ω denotes an angular velocity of the BLDC motor.

15. A speed determination unit for a brushless dc (BLDC) motor speed control apparatus, comprising:

a flux determination unit to determine fluxes based on induced voltages and currents of windings corresponding to two phases of three phases of the BLDC motor; and

a speed calculation to determine specific periods of the fluxes of the respective phases outputted from the flux determination unit and calculating a speed of the BLDC motor.

16. The apparatus as claimed in claim 15, wherein the flux determination unit comprises:

a current detector to detect the induced voltages and currents corresponding to the two phases of the three phases of the current driving the BLDC motor;

a phase transformer to transform the induced voltages and currents of the two phases into induced voltages and currents of first and second transformed phases; and

a flux determiner to determine fluxes of the first and second transformed phases based on the induced voltages and currents of the first and second transformed phases outputted from the phase transformer.

17. The apparatus as claimed in claim 16, wherein the speed calculation unit comprises:

a timer to determine a period between when the flux of the first transformed phase becomes a specific value and when the flux of the second transformed phase becomes the specific value; and

a speed determiner to determine a rotation speed of the motor based on the period determined by the timer.

18. The apparatus as claimed in claim 17, wherein the specific value is '0'.

19. A speed determination unit for a brushless dc (BLDC) motor speed control apparatus, comprising:

a current detector to detect induced voltages and currents corresponding to two phases of three phases of current driving the BLDC motor;

a phase transformer to transform the induced voltages and currents of the two phases of the three phases into induced voltages and currents of first and second transformed phases;

a flux determiner to determine fluxes of the first and second transformed phases based on the induced voltages and currents of the first and second transformed phases outputted from the phase transformer;

a timer to determine a period between when the flux of the first transformed phase becomes a specific value and when the flux of the second transformed phase becomes the specific value; and

a speed determiner to determine a rotation speed of the motor based on the period determined by the timer.

20. The apparatus as claimed in claim 19, wherein the specific value is '0'.

21. A speed determination unit for a brushless dc (BLDC) motor speed control apparatus, wherein:

the speed determination apparatus determines and controls a BLDC motor speed without a speed sensor and a speed sensor driver.